

# Programmable 2-Dimensional Microshutter Arrays

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We are developing a two-dimensional array of microshutters which can be used as a high efficiency, high contrast field selection device for a multi-object spectrometer for the Next Generation Space Telescope (NGST). The device is a close-packed array of shutters, with a typical size of 100 microns square and area filling factor of up to 80%. Each shutter, made of single crystal silicon with an appropriate optical coating, pivots on a torsion flexure along one edge. Each of the shutters is individually selectable. An original double-shutter mechanism is employed for actuation. Since the device works in transmission, there is no loss of contrast due to diffraction from the edges of unactuated pixels. When working in reflection, the device can also be used as a micromirror array.

## Proposed transmissive micro-shutter design:

- 512 x 512 (2048 x 2048) array
- 80% fill factor
- 100 by 100  $\mu\text{m}$  blade
- Torsion beam edge suspension for 90 degree rotation
- Double shutter actuation

## Potential applications:

- Multi object radiation spectroscopy
- Variable input field mass spectroscopy
- Most things micromirrors can do

## Current status:

- Analyzed materials stiffness and strength
- Optimized torsion beam geometry
- Produced 5x5 arrays in Si-frame mounted membranes by ion milling
- Demonstrated 3x3 shutter actuation with micromanipulator in electron microscope

## High strength membrane materials:

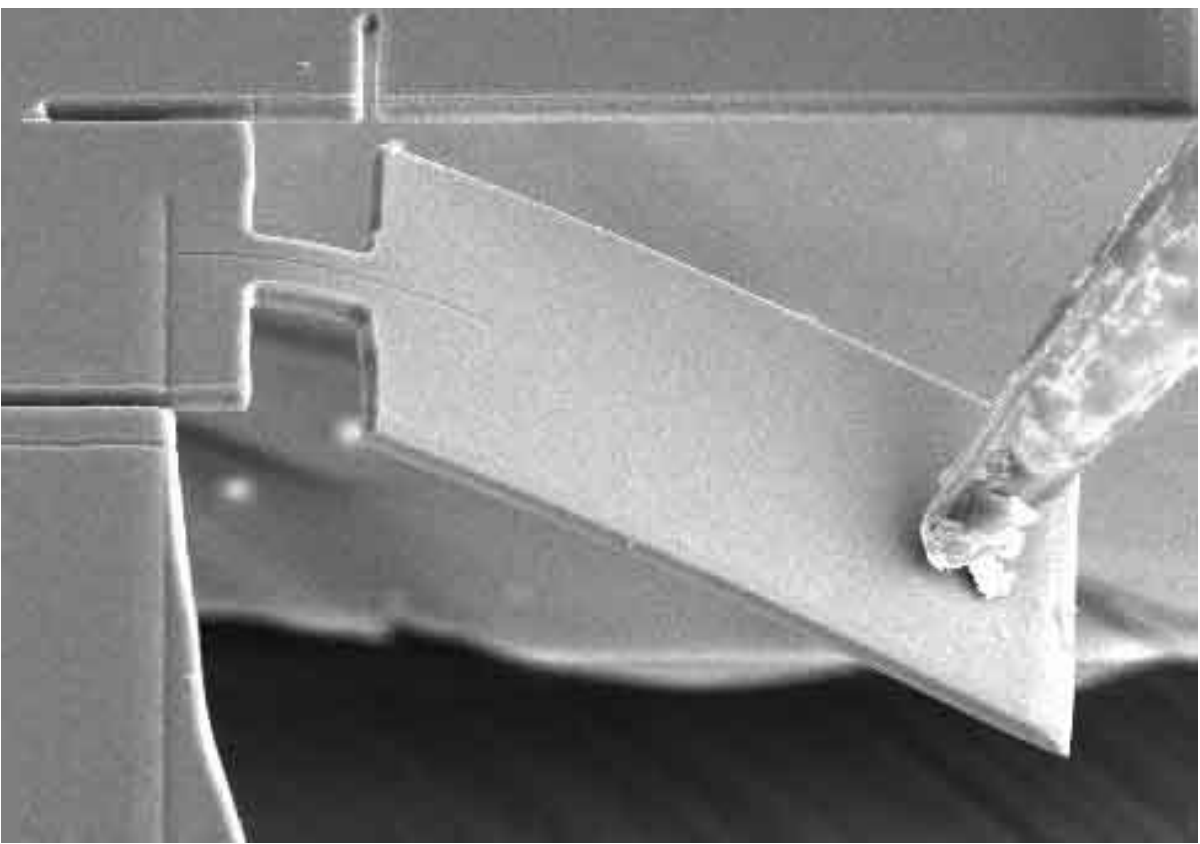
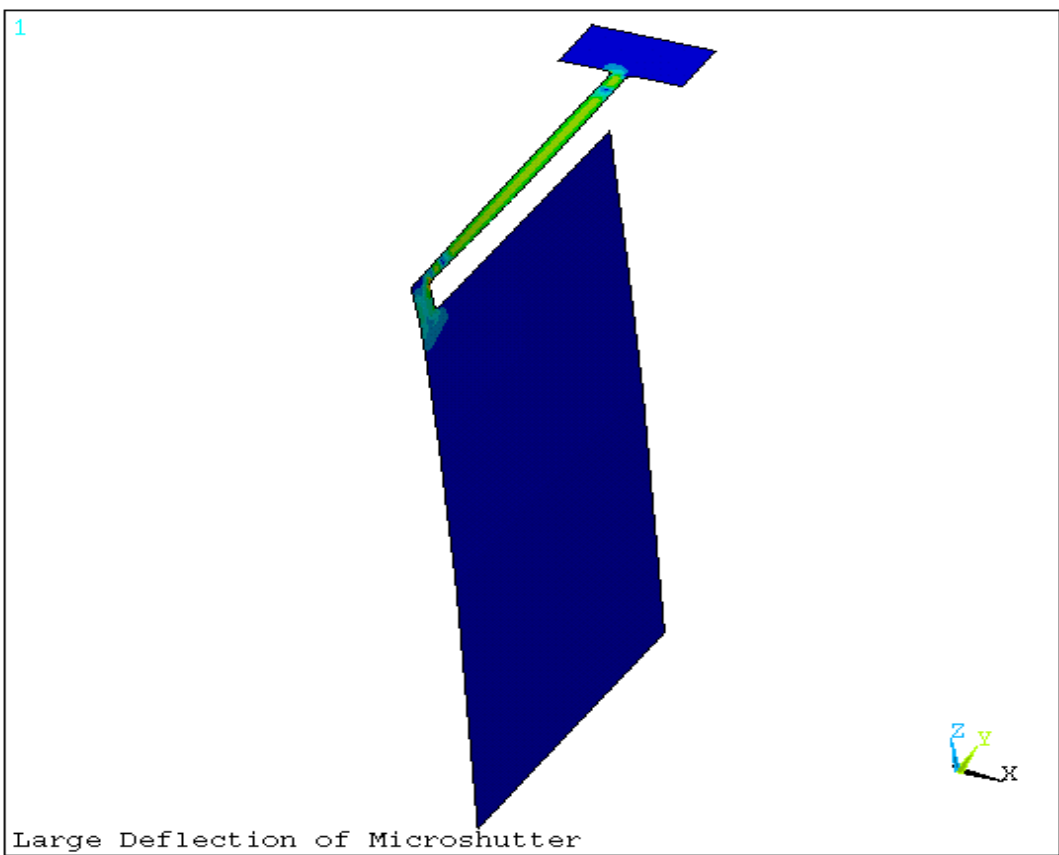
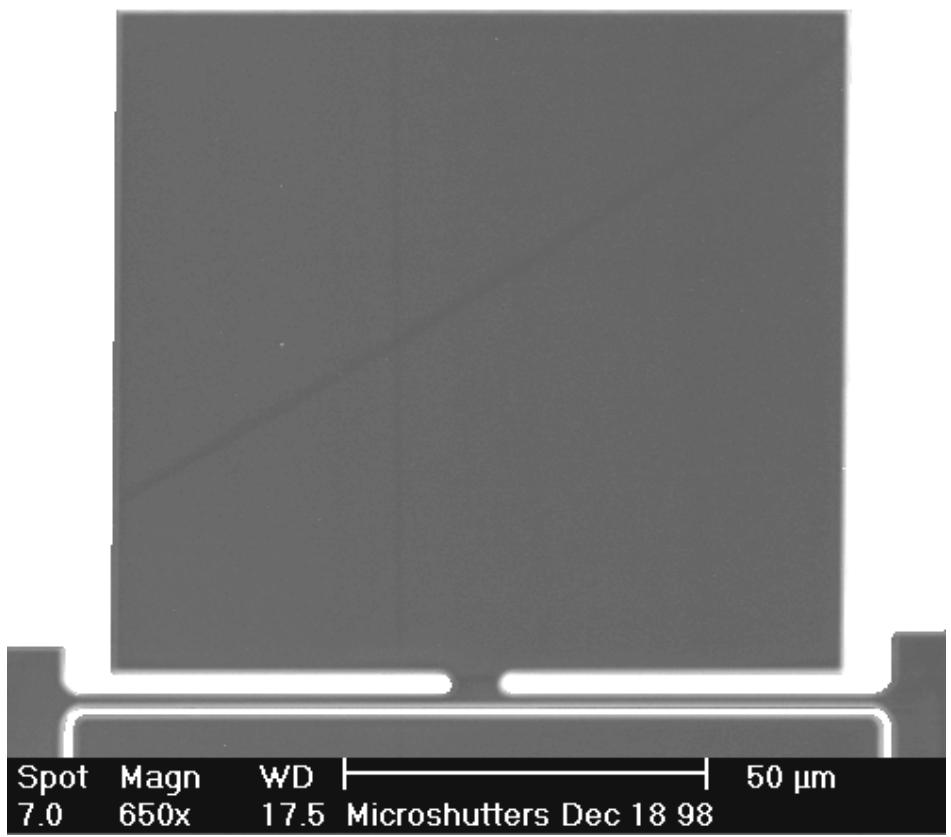
- Single crystal silicon - 2.0  $\mu\text{m}$  thick
- Low stress CVD silicon nitride - 0.5  $\mu\text{m}$  thick

## Microfabrication and testing was performed in a FEI 620 machine with:

- Focused ion beam milling
- *In situ* scanning electron microscopy
- Ion induced MOCVD platinum deposition
- Micro-manipulated needle

## Future Development:

- 128x128 mechanical model in lithography
- 32x32 DRAM addressable model in CMOS
- 30K testing with 2D actuator
- 4 bar linkage double shutter suspension
- 512x512 fully addressable array



## Calculation of stress and measurement of fracture limits form the base to determine torsion beam dimensions. For details see:

R.K. Fettig, J.L. Kuhn, S.H. Moseley, A.S. Kuttyrev, J. Orloff, and S. Lu, "Some Aspects on the Mechanical Analysis of Micro-shutters," in *Micromachining and Microfabrication, Proceedings of SPIE* 3875-26, Sept. 1999.

Perimeter images: Color enhanced SEM pictures of 3x3 on 5x5 microshutters in different positions of actuation, fully and partially open. Shutters were fabricated and actuated in a combined focused ion beam/ SEM machine (FEI 620). Membrane material is silicon nitride.

